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According to the above-mentioned fifth embodiment of the present invention, the sensitivity can be improved by increasing the conversion efficiency while suppressing the occurrence of a dark current and a white spot.

While the n-channel MOS transistor is applied as respective pixel transistors to the solid-state imaging device according to the above-described embodiments, the present invention is not limited thereto, and a p-channel MOS transistor can be applied to the solid-state imaging device as a pixel transistor. In the case of the n-channel MOS transistor, the n-type is set to the first conductivity type and the p-type is set to the second conductivity type in the above-mentioned embodiments. In the case of the p-channel MOS transistor, the p-type is set to the first conductivity type and the n-type is set to the second conductivity type. That is, the n-channel and the p-channel have opposite conductivity types.

Also, the above-described embodiments of the present invention are applied, for example, to the area sensor in which pixels are arrayed in a two-dimensional matrix. The present invention is not limited to the application to the area sensor and can be applied to a linear sensor (line sensor) in which the above-described pixels are linearly arrayed one-dimensionally.

FIG. 16 is a schematic cross-sectional view showing a camera according to an embodiment of the present invention. The camera according to the embodiment of the present invention is a video camera capable of capturing still images or moving images, for example.

As shown in FIG. 16, the camera according to the embodiment of the present invention includes a MOS image sensor 10, an optical system 210, a shutter device 211, a drive circuit 212 and a signal processing circuit 213.

The optical system 210 focuses image light (incident light) reflected from an object on an imaging screen of the MOS image sensor 10. As a result, signal electric charges are accumulated in the MOS image sensor 10 for a specific period.

The shutter device 211 is configured to control a light irradiation period and a light shaded period for the MOS image sensor 10.

The drive circuit 212 is configured to supply drive signals to control transfer operations of the MOS image sensor 10 and shutter operations of the shutter device 211. The MOS image sensor is configured to transfer signals upon receiving a drive signal (timing signal) supplied from the drive circuit 212. The signal processing circuit 213 is configured to carry out various kinds of signal processing. An image signal obtained after signal processing is stored in a storage medium, such as a memory, or outputted to a monitor.

The above-described solid-state imaging device according to the embodiments of the present invention, specifically, the MOS image sensor, is suitable for the application to a solid-state imaging device mounted on mobile devices, such as a mobile phone unit with a camera and a PDA.

In particular, according to the embodiments of the present invention, the conversion efficiency can be improved while suppressing the occurrence of a dark current and a white spot, if the area of the photodiode, which is the photoelectric conversion element, is miniaturized along with the pixel size being reduced as the number of pixels is increased.

It should be understood by those skilled in the art that various modifications, combinations, subcombinations and alterations may occur depending on design requirements and other factors insofar as they are within the scope of the appended claims or the equivalents thereof.

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What is claimed:

1. An imaging device comprising:

a plurality of photoelectric conversion elements including a first photoelectric conversion element and a second photoelectric conversion element;

a floating diffusion portion;

a first transfer transistor configured to transfer charges generated in the first photoelectric conversion element to the floating diffusion portion;

an impurity diffusion isolation region formed between the first photoelectric conversion element and the second photoelectric conversion element; and

a first discrete trench isolation structure, wherein the floating diffusion portion contacts a portion of the first discrete trench isolation structure,

a gate electrode of the first transfer transistor covers a portion of the first discrete trench isolation structure, and

the first discrete trench isolation structure is not in contact with the first photoelectric conversion element.

2. The imaging device according to claim 1, further comprising a second transfer transistor configured to transfer charges generated in the second photoelectric conversion element to the floating diffusion portion.

3. The image device according to claim 1, further comprising a reset transistor disposed between the floating diffusion portion and a predetermined voltage.

4. The imaging device according to claim 3, wherein the first discrete trench isolation structure is in contact with the reset transistor.

5. The imaging device according to claim 3, further comprising a selection transistor, wherein a gate electrode of the selection transistor is connected to the floating diffusion portion.

6. The imaging device according to claim 1, wherein the first discrete trench isolation structure is formed by a shallow trench structure.

7. The image device according to claim 1, wherein the gate electrode of the first transfer transistor includes polysilicon.

8. The imaging device according to claim 1, wherein the impurity diffusion isolation region is different shape structure from the first discrete trench isolation structure.

9. The imaging device according to claim 1, further comprising a planarized insulating film formed on the first discrete trench isolation structure and the impurity diffusion isolation region.

10. The imaging device according to claim 9, wherein a film thickness of the planarized insulating film is greater than or equal to a film thickness of a gate-insulated film.

11. The imaging device according to claim 1, wherein the first photoelectric conversion element is not directly in contact with the floating diffusion portion.

12. The imaging device according to claim 1, further comprising a second discrete trench isolation structure on an opposite side of the floating diffusion as the first discrete trench isolation structure.

13. A camera device, comprising:

an optical system;

an imaging device including:

a plurality of photoelectric conversion elements having a first photoelectric conversion element and a second photoelectric conversion element,

a floating diffusion portion,

a first transfer transistor configured to transfer charges generated in the first photoelectric conversion element to the floating diffusion portion,